J.C. Schuchman
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VACUUM SYSTEM FOR THE H-10 EJECTOR MAGNET ASSEMBLY

Summary

This note describes the technique for pumping the new H-10 ejector magnet assembly.

The technique is to condition the magnet and box assembly prior to its installation in the ring. The conditioning is a mild bakeout of the magnet assembly while under vacuum. The bakeout will be at 250°F for 24 hours. The vacuum system proper will consist of four small ion pumps, (150-200 ℓ/sec) connected directly to the box without valves. After conditioning, the assembly will remain under vacuum until it is scheduled for installation in the ring. At that time, it will be vented with dry nitrogen and the entire assembly, box, magnet, pumps, etc., will be installed as a single unit. The operating pressure is calculated as below the design pressure of 1×10^{-6} torr.

Discussion

As with any vacuum system, the most difficult quantity to estimate or measure is the gas load; that is, the outgassing rates of the various components which make up the assembly. Therefore, calculations are based on the performance of F10 as well as outgassing rates measured on the "dry-stacked" and the "epoxy" magnet assemblies. The "dry-stacked" magnet refers

to the magnet assembly which used an oxide film to insulate the laminations while the "epoxy" magnet used epoxy in addition to an oxide film between laminations.

Starting with the lowest recorded operating pressure at the F-10 box of 1.7×10^{-6} torr and assuming a total pumping speed at the F-10 box of 490 ℓ/sec, the gas load pumped is Q = PS = $(1.7 \times 10^{-6}$ torr) (490 ℓ/sec) = 8.3×10^{-4} Tℓ/sec. This is for an epoxy magnet. Since a dry-stacked magnet will be used at H-10, this number must be adjusted to suit. Relative outgassing rate measurements made on sample magnets show that the dry-stacked magnet outgasses about 2.4 times more than the epoxy magnet, see Fig. 1. Therefore, the total gas load anticipated for H-10 is

$$(2.4) \ (8.3 \times 10^{-4}) = 20 \times 10^{-4} \ \text{T}\ell/\text{sec}.$$

If an operating pressure of 1×10^{-6} torr is desired then the required pumping speed is $\dfrac{Q}{P} = \dfrac{20 \times 10^{-4}}{1 \times 10^{-6}} = 2000 \ \ell/\text{sec}$.

One means of obtaining this speed is to use two 1500 ℓ/sec pumps which would have an effective speed of 2000 ℓ/sec. Another solution, and the one taken here, is to reduce the gas load, and hence the required pumping speed, by baking the entire magnet assembly. Our tests have shown that the outgassing rate of the dry-stacked magnet can be reduced 75% by baking the magnet at 200°F for 24 hours, see Fig. 2. Applying this reduction to the H10 gas load, $(20 \times 10^{-4} \ \text{T}\ell/\text{sec})$ (25%) = 5×10^{-4} Tℓ/sec. If four small pumps (200 ℓ/sec) are now used on the box, a total of 780 ℓ/sec is available. Therefore, a base pressure of a baked out magnet assembly would be

$$\frac{5 \times 10^{-7} \ \text{T}\ell/\text{sec}}{780 \ \ell/\text{sec}} = 6.4 \times 10^{-7} \ \text{torr}.$$

If one pump was inoperative the effective speed would be reduced to 590 ℓ/sec and the pressure would be

$$\frac{5 \times 10^{-4}}{590} = 8.5 \times 10^{-7} \text{ torr.}$$

It is important to point out that all of the above calculations are based on data measured after a couple of days of pumping. Figure 3 shows a pump down curve for the AGS half superperiod mock-up,[1] which may be considered as typical for the converted AGS. It shows a nominal operating pressure in the 10^{-7} torr area. I would estimate that the pressure in a typical 10 ft box, such as we are discussing, will follow the AGS pump down curve, but will be higher by a factor of about five. This would indicate that after five hours of pumping the 10 ft box would be below 5×10^{-5} torr which is the high pressure cut off point for the AGS.
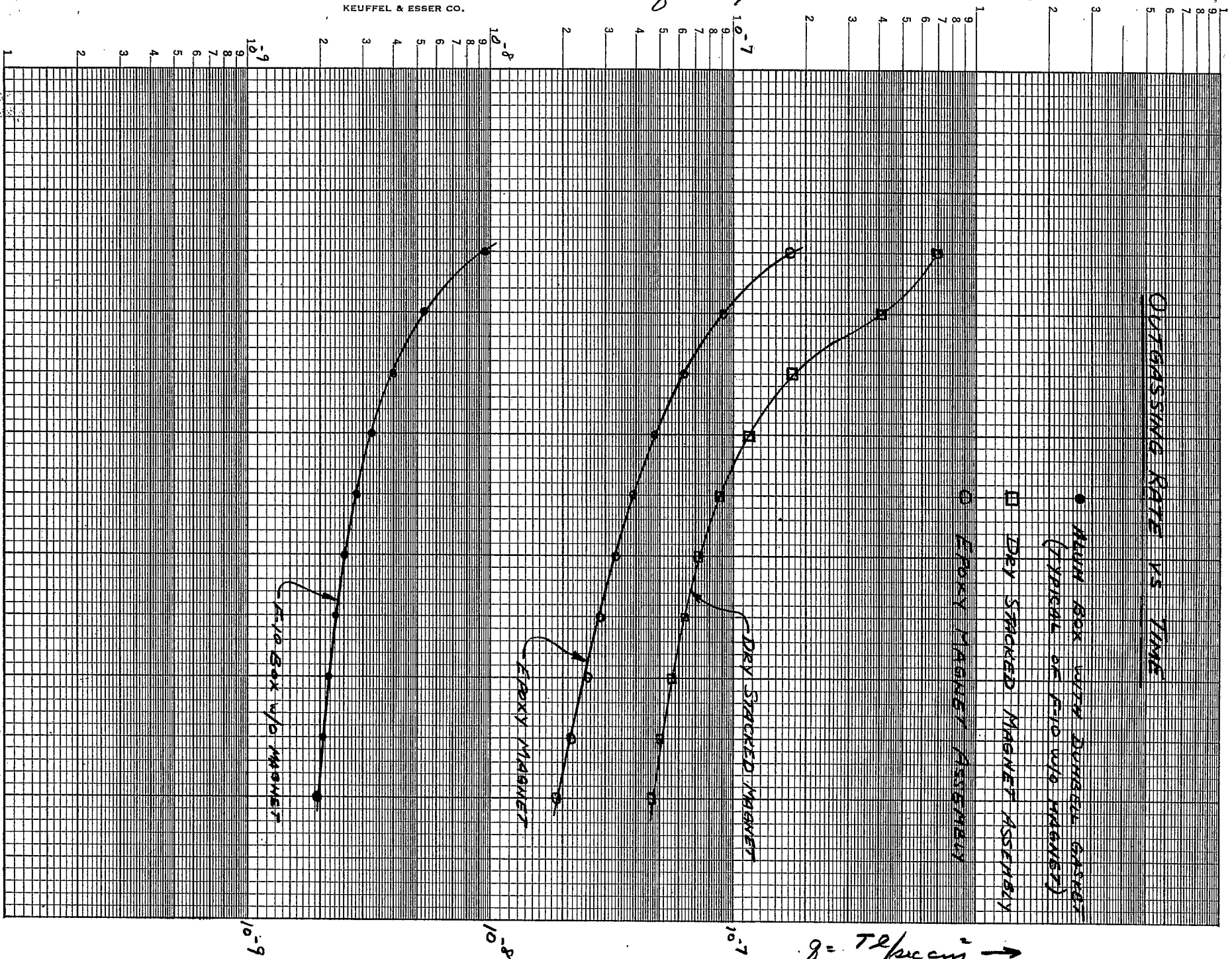
References

1. T. Carides and J.G. Cottingham, "Wet vs Dry Venting of a Vacuum Chamber," AGSCD Technical Note No. 81, June 1967.

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Fig. 1

OUTGASSING RATE VS TIME

● HIGH BOX WITH DIFFUSED GASKET
  (TYPICAL OF F-10 W/O MAGNET)

□ DRY STACKED MAGNET ASSEMBLY

○ EPOXY MAGNET ASSEMBLY

$g = T\ell/sec\ cm^2$

TIME hours

"I-10 BOX W/O MAGNET"

"EPOXY MAGNET"

"DRY STACKED MAGNET"

$g = T\ell/sec\ cm^2$

J.C.S

DRY STACKED MAGNET

BEFORE BAKEOUT

AFTER BAKEOUT

BAKED MAGNET FOR 24 HOURS
AT 200°F UNDER ARGON ATMOSPHERE
VENTED TO ROOM AIR FOR 3 HOURS
PUMPED DOWN AND RECORDED ABOVE
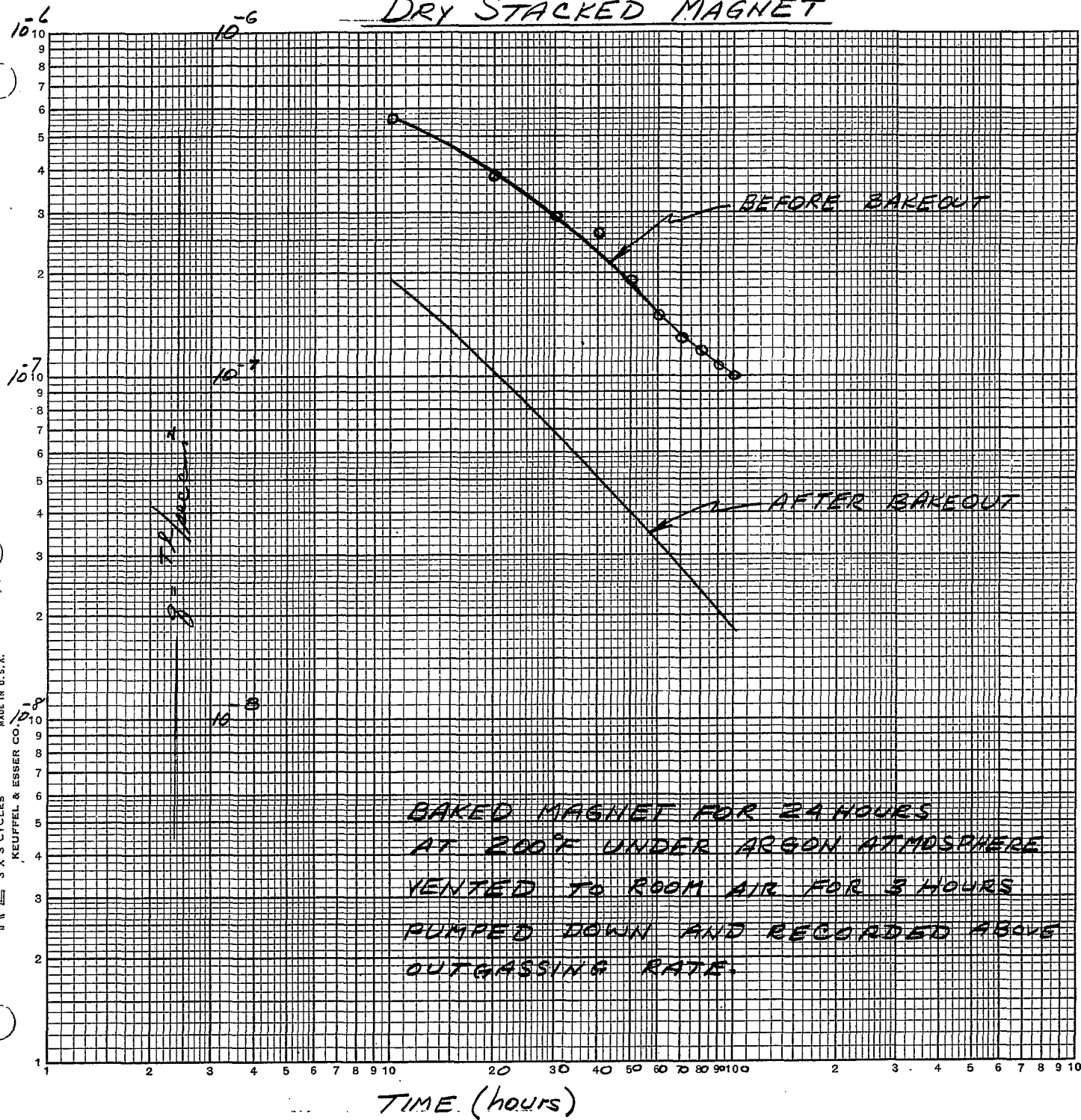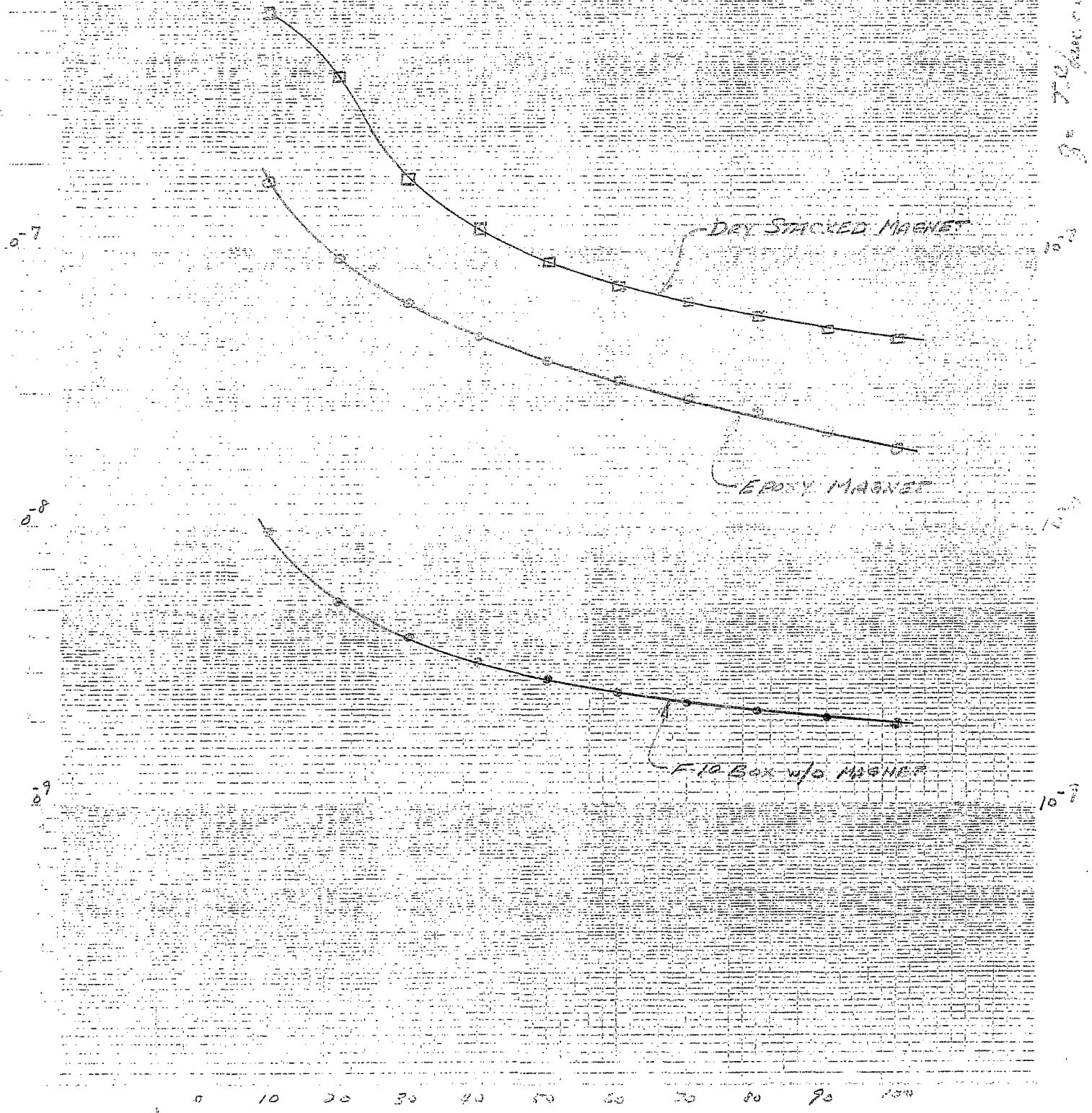OUTGASSING RATE.

TIME (hours)

Fig 2   OUTGASSING RATE OF DRY-STACKED
MAGNET BEFORE AND AFTER BAKE

OUTGASSING RATE vs TIME

○ ALUM BOX WITH DUMBELL GASKET
(TYPICAL OF F-10 w/o MAGNET)

□ DRY STACKED MAGNET ASSEMBLY
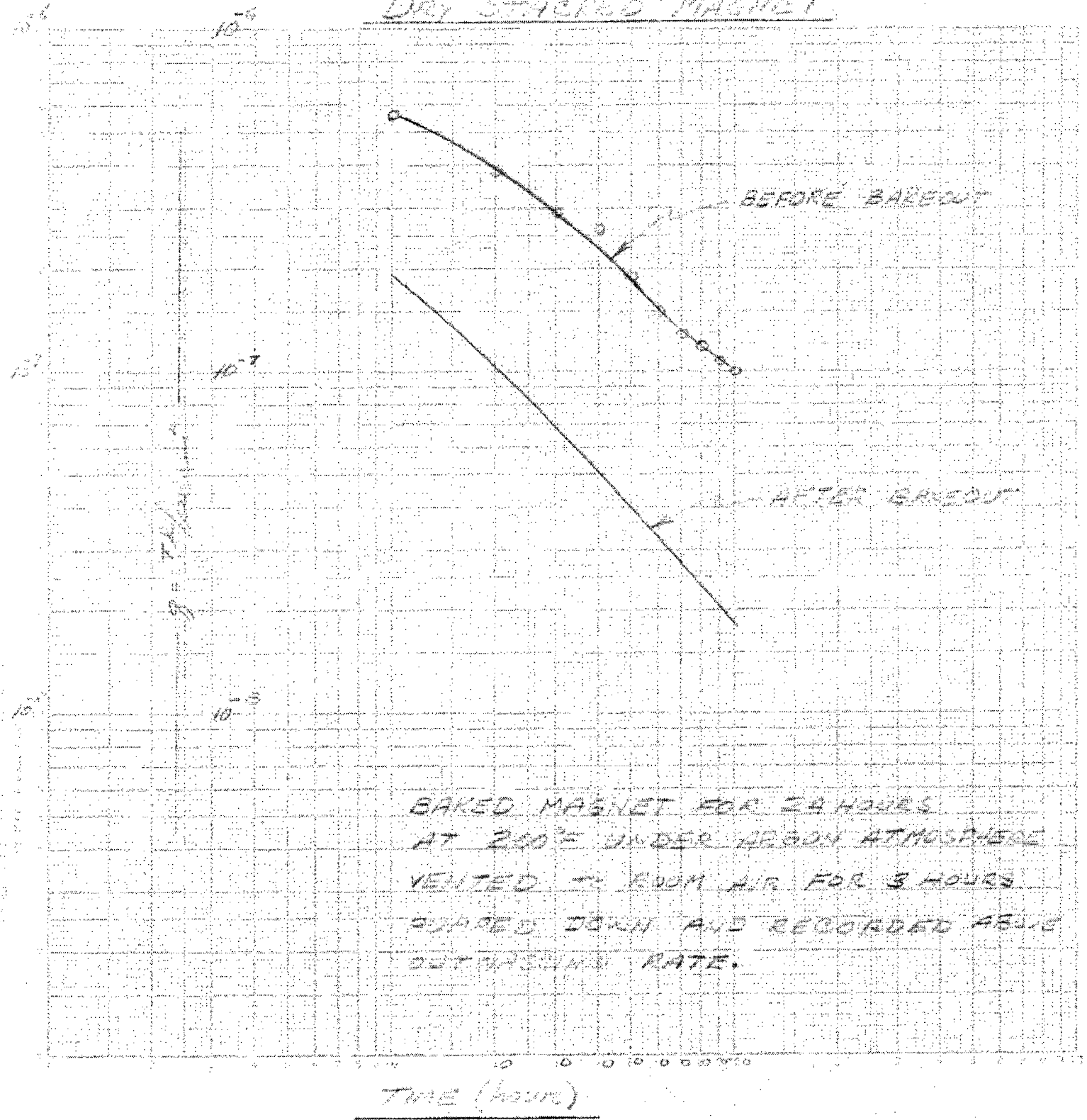
○ EPOXY MAGNET ASSEMBLY

DRY STACKED MAGNET

EPOXY MAGNET

F-10 BOX w/o MAGNET

10^{-7}

10^{-8}

10^{-9}

0   10   20   30   40   50   60   70   80   90   100

BEFORE BAKEOUT

AFTER BAKEOUT

BAKED MAGNET FOR 24 HOURS
AT 200°C UNDER ARGON ATMOSPHERE
VENTED TO ROOM AIR FOR 3 HOURS
COOLED DOWN AND RECORDED PRESSURE
OUTGASSING RATE.

Time (hours)

Fig. 2   Outgassing Rate of Dry-Sintered
Magnet Before and After Bake

Curve I: Vented to nitrogen approx. 16 hours.

Curve II: Vented to atmosphere approx. 16 hours.

Curve III: Vented to nitrogen followed by 4 hours exposure to atmosphere.

Note: Test points marked x are for an intermediate pump-down run
       just before that for Curve III. Venting conditions were:
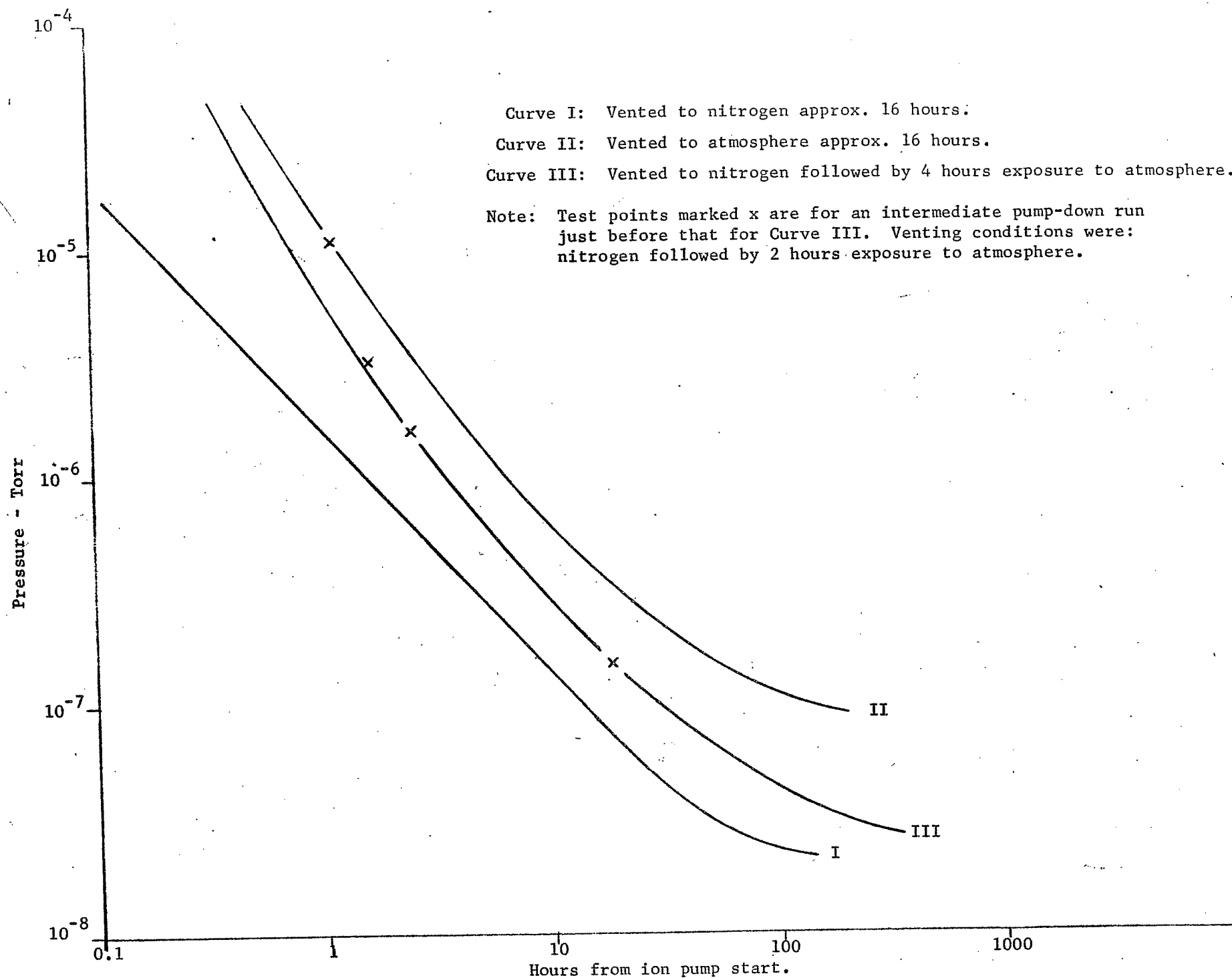   nitrogen followed by 2 hours exposure to atmosphere.

Fig. 3. Pump-down characteristics for various venting conditions.